International Symposium
Agro-industrial uses of banana and plantain fruits
15-17th of May 2006

Colima (Mexico)

Industrial uses of starch

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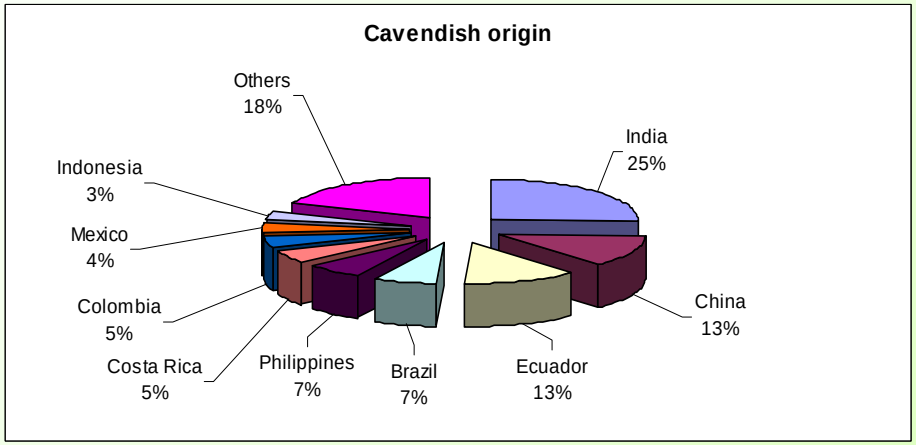
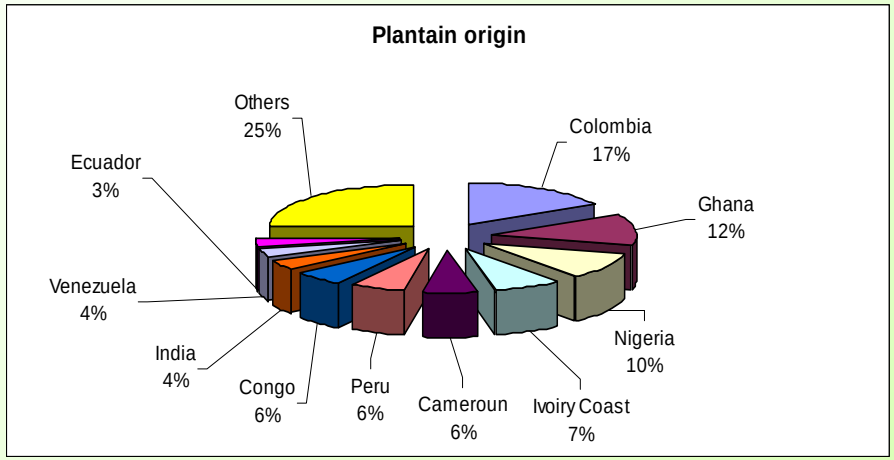
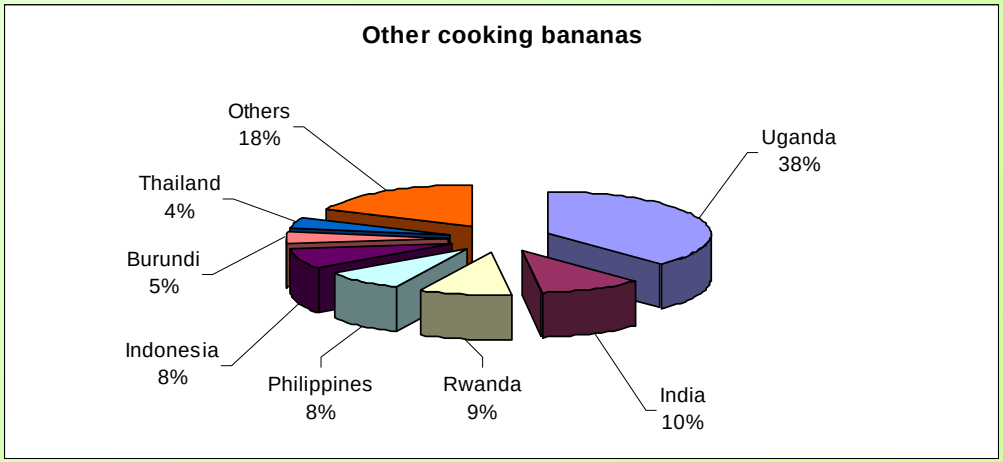
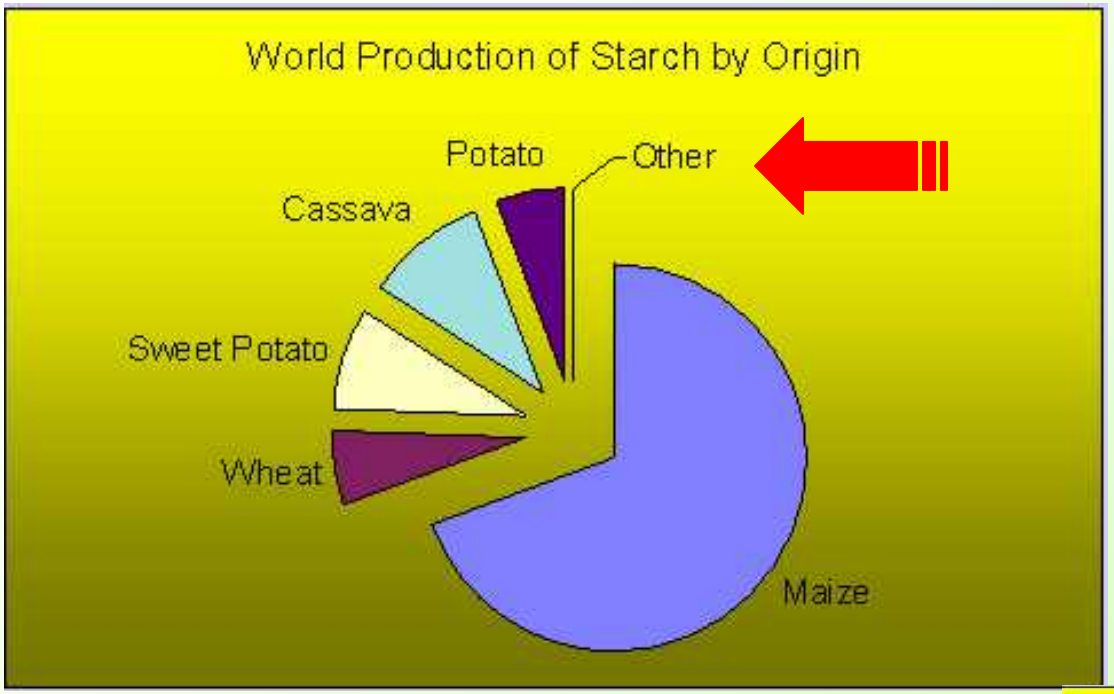
Banana production by origin



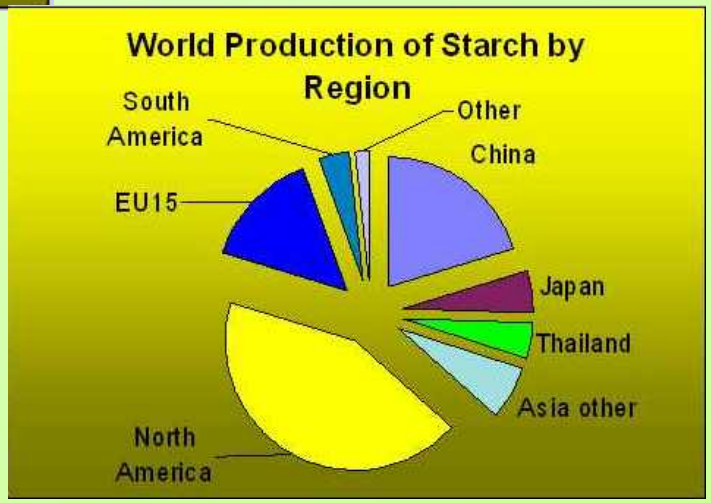




Distribution of starch by origin and region



World production of starch = 60 millions of tonnes in 2004

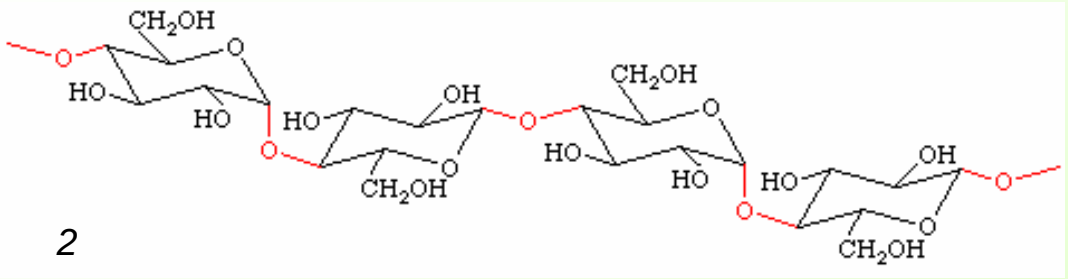


Composition of various high starch sources

Product	Starch (%)*	Proteins (%)*	Lipids (%)*	Fibers (%)*	Ashes (%)*	Water (%)
Potato	84	8	0.5	3	4	78
Cassava	95	1	0.5	2	1.5	12
Wheat Rice Corn	75	12 8 12	3	3	2	12
Pea	60-66	25-30	1.5	6-8	1.5-3	75
Banana	70-85	5	1.5	2	3.5	74

** Dry weight basis*

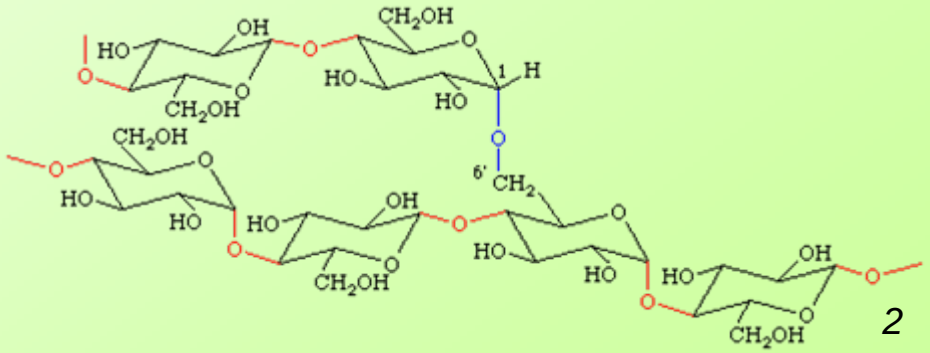
Amylose and amylopectin



Amylose : a linear polymer

1-4 linked α-D-glucopyranosyl units or seldom branch with α-D-1-6 linkages [1]

Amylopectin : highly branched polymer



D-glucopyranosyl units linked by 1-4 bonds with 1-6 linkage branches [1]

Various amylose, amylopectin contents of starch

Starch type	Amylose (%)	Amylopectin (%)
Corn	25-28	72-75
Cassava	17-20	80-83
Potato	20-23	77-80
Rice	15-35	65-85
Wheat	20-26	74-80
Waxy corn (*)	0	100
Banana	15-23	77-85
Plantain	9-17	83-91

(*) Genetically modified starch

Banana starch small scale production and derivatives

1/5 of all bananas harvested become culls

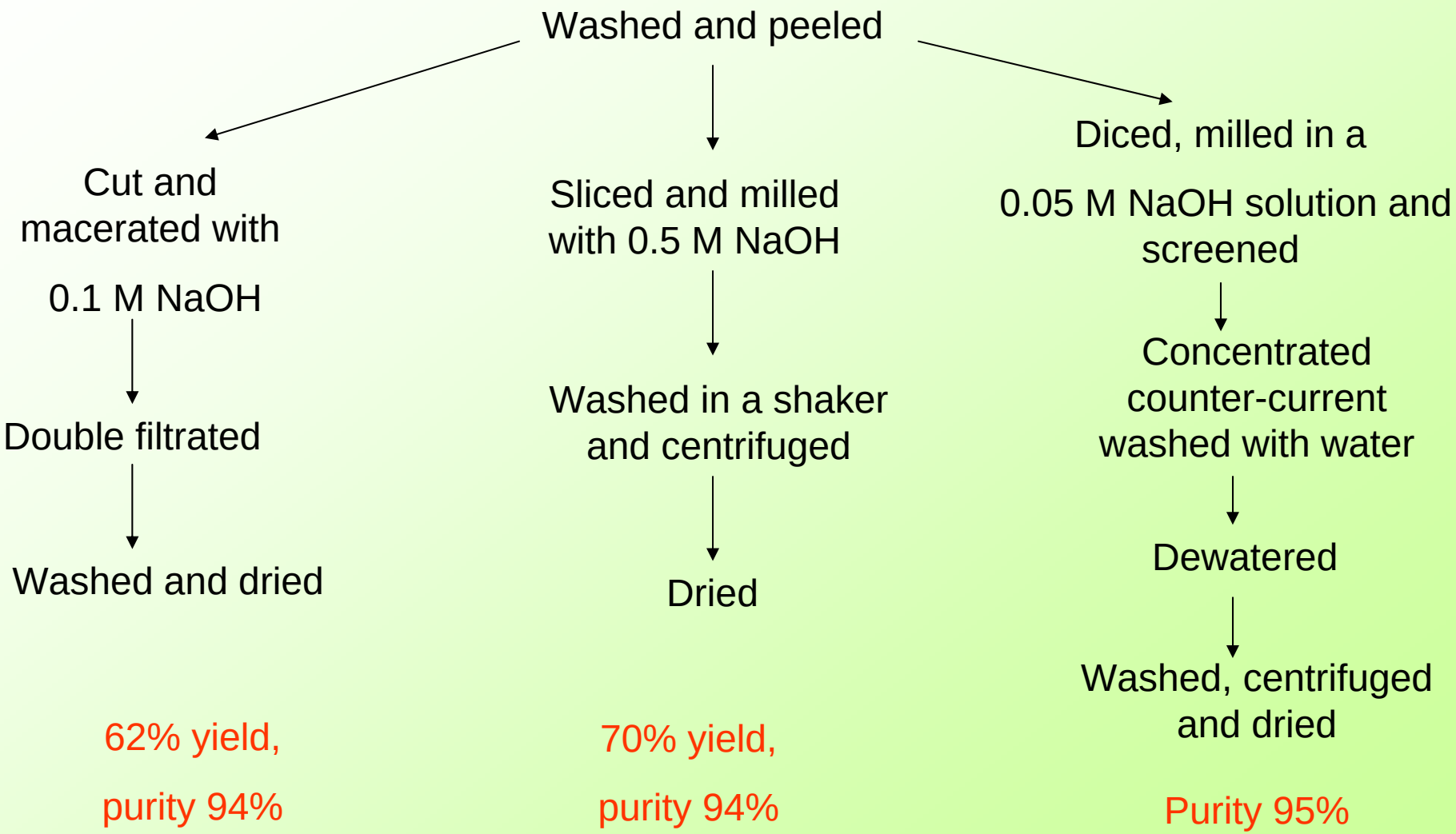
Industrial use of culled bananas = a challenge

Potential practical application :

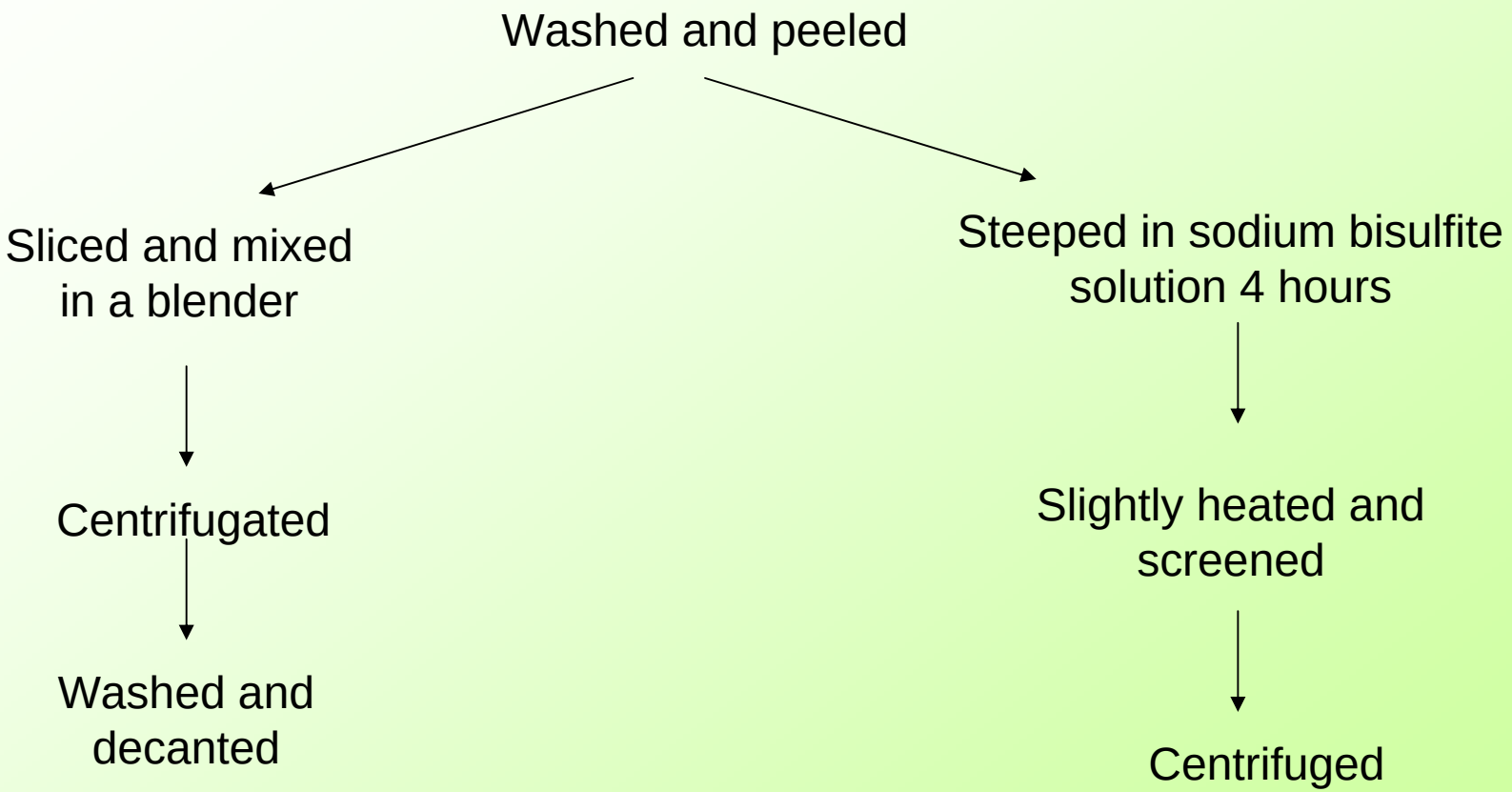
1) Pulp processing for starch production by wet milling

2) Structure and functionalities investigations
   - low cost banana flour ingredient processing
   - formulated banana flour with cassava or yam (fufu,..)
   - by-products valorisation (dietary fibre from peel, pectic polysaccharides and hemicellulose)

Rejected cull bananas alkaline process



Rejected cull bananas non-alkaline process



Purity 99.5%

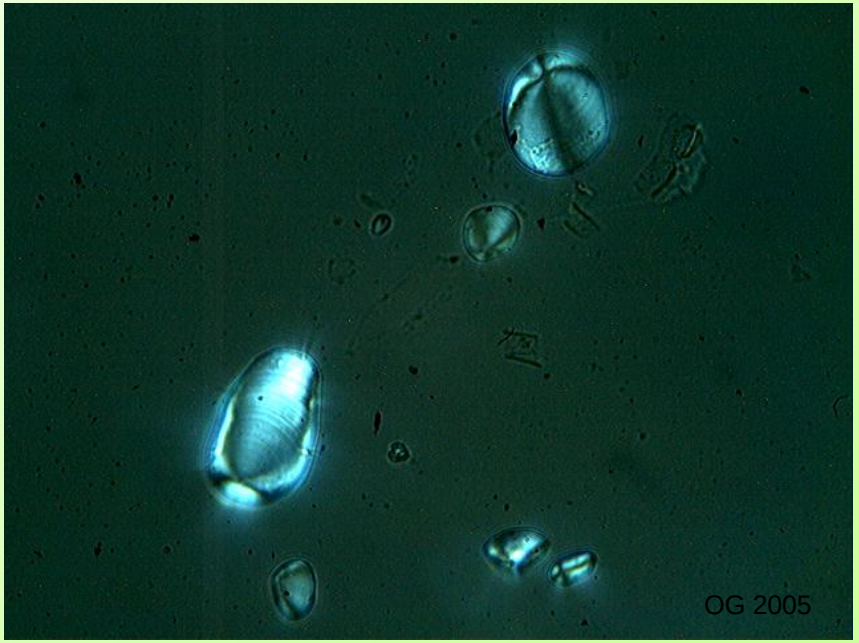
20-60% yield depending on ripeness

Banana starch granule

Irregular in shape and size (5-58μm) [1]

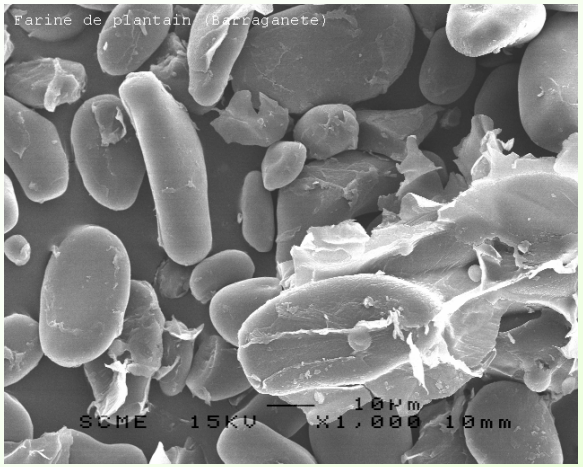
smooth cell walls [2]

Excentric hila and birefringence [3]



Heat effect on Starch

Native barraganete flour

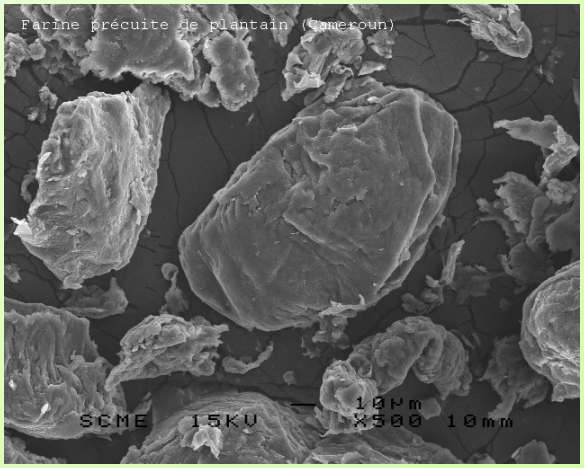


— 10 µm

Native dominico flour

— 10 µm

Pre-cooked plantain flour



— 10 µm

Banana pulp tissue

Plantain pulp tissue

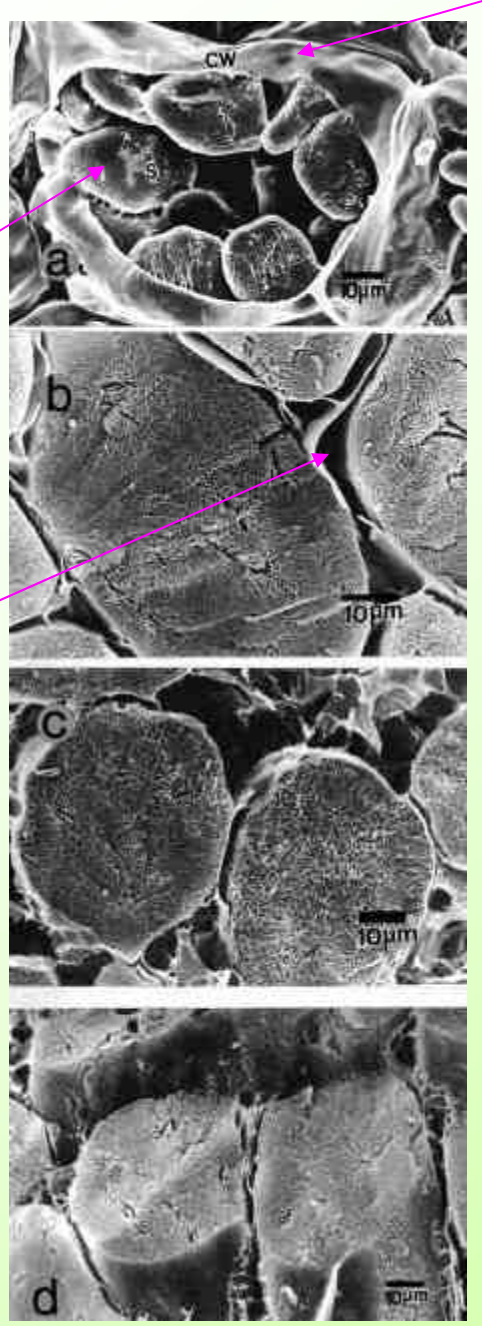
Cell wall

Starch granule

Cell wall expansion

Starch granule

Cell wall expansion

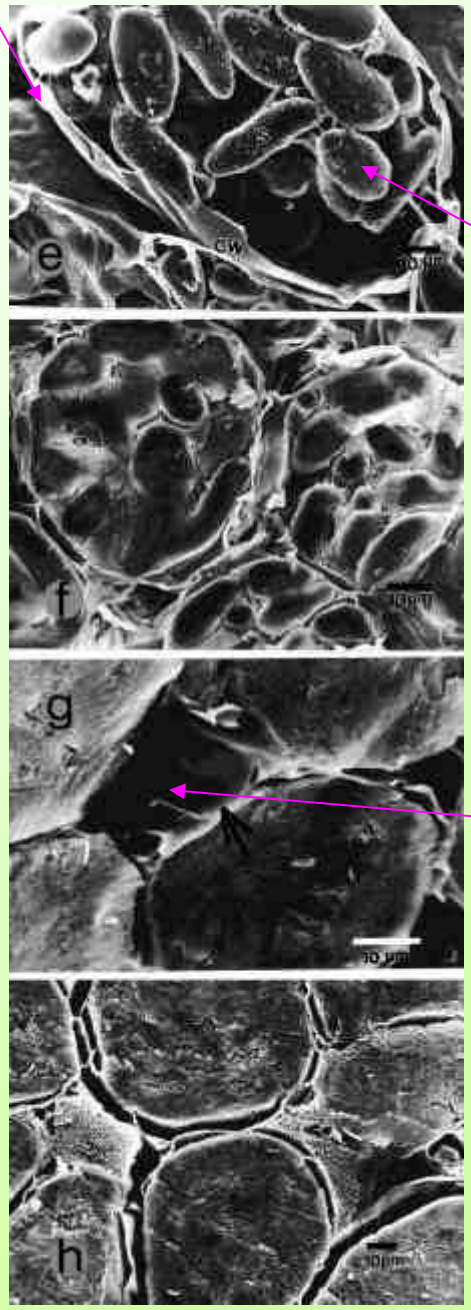


Native

2 min heating

3 min heating

8 min heating

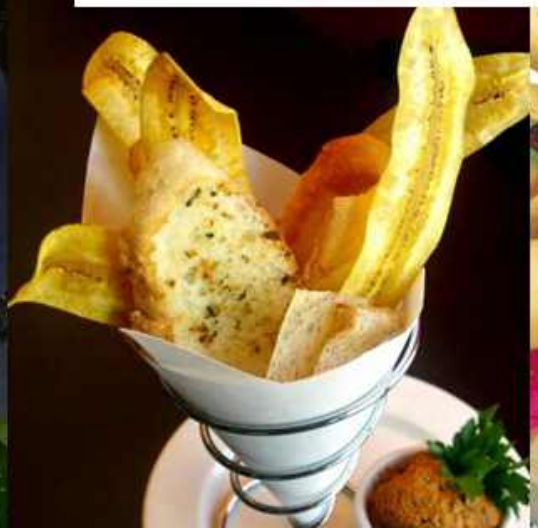










Starch functional properties

Depends on :

- Gelatinisation characteristics;

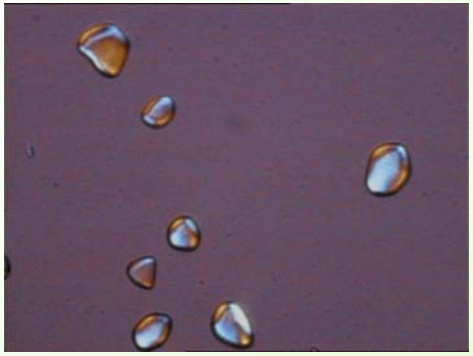
- Pasting characteristics;

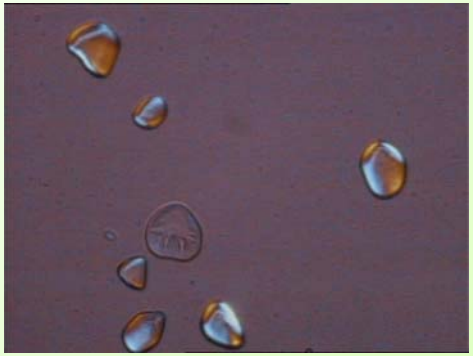
- Swelling power and solubility (influenced by amylose/amylopectin ratio and ripening stage);

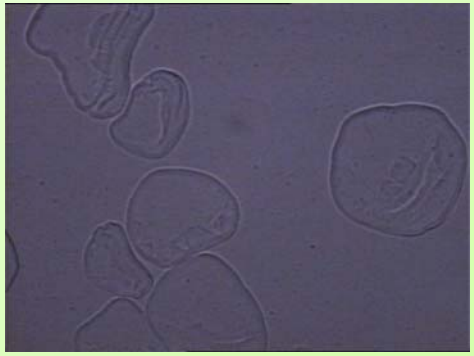
- Rheology (shear rate on viscosity).

Gelatinisation

« Order to disorder phase transition with heat and excess of water »







Water diffusion into the granule

Starch granule swelling

Loss of birefringence and cristallinity

Heat uptake

Amylose leaching

Pasting

= the consequence of the gelatinisation

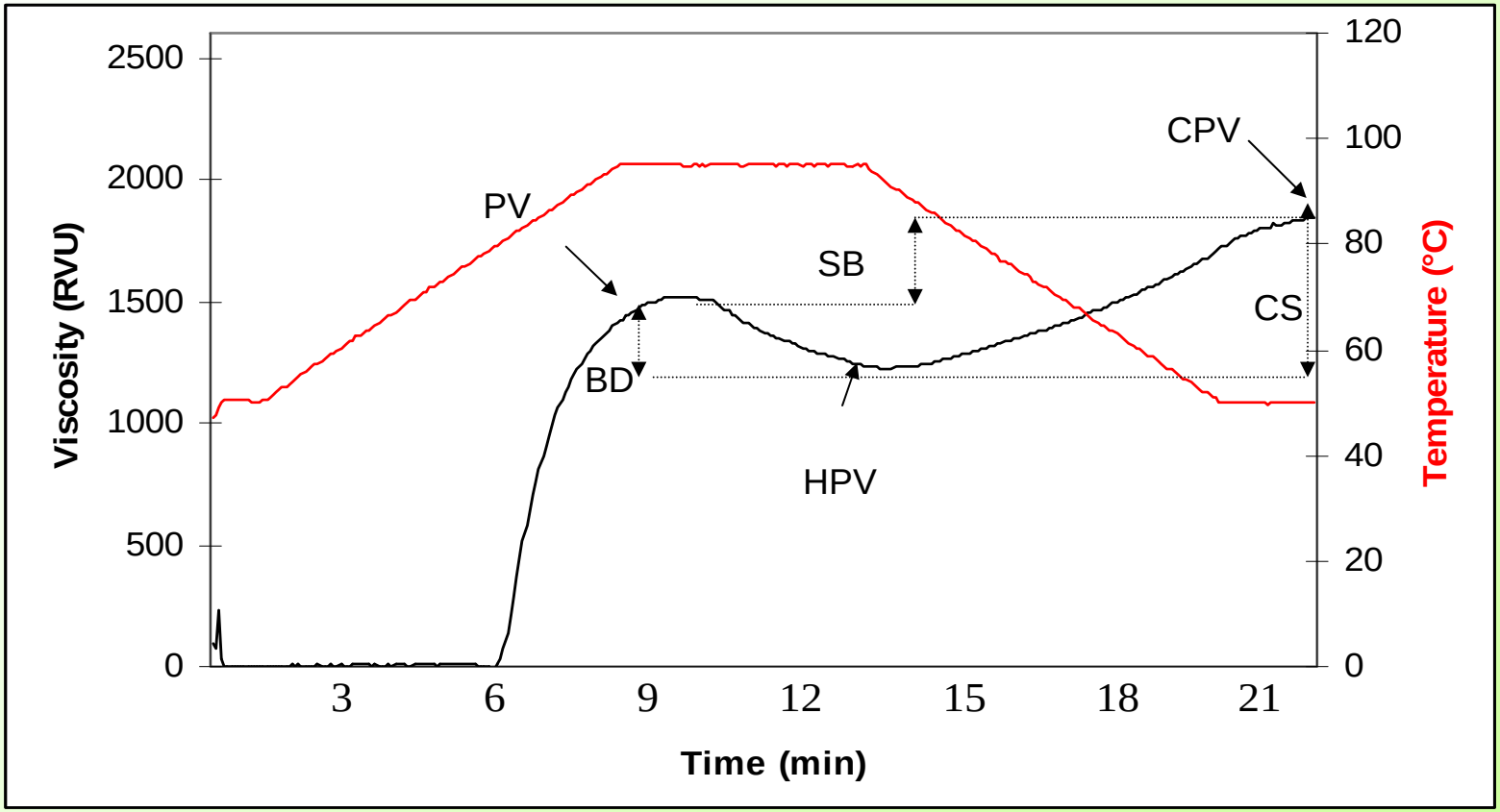
Swollen granules entrapped by amylose-amylopectin network with presence of fragments of starch structures

⇒Viscosity and gel characteristics

⇒Amylose and amylopectin retrogradation during cooling

⇒Gel forming (with more or less hardness depending on cultivar)

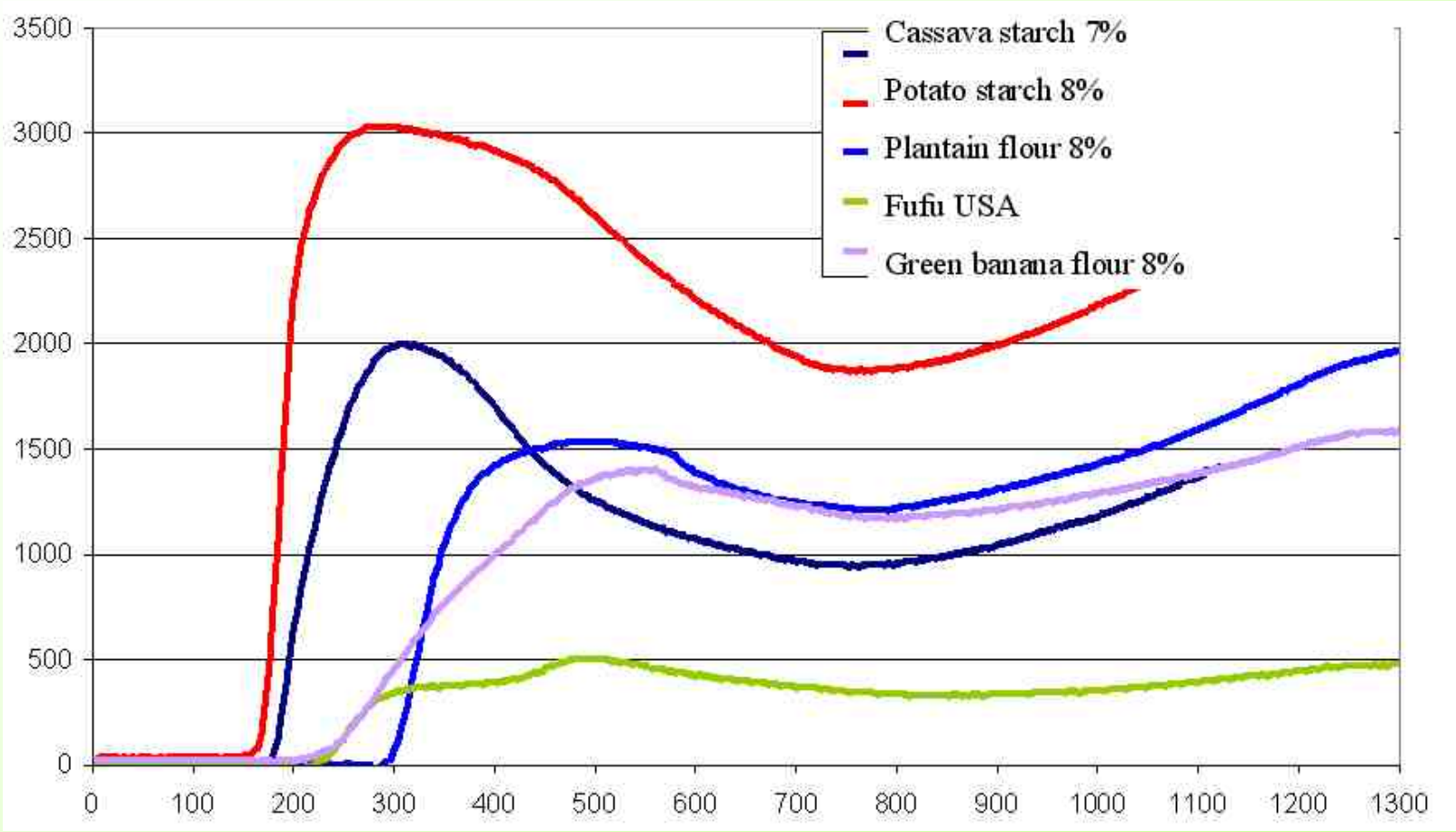
Pasting profile using RVA



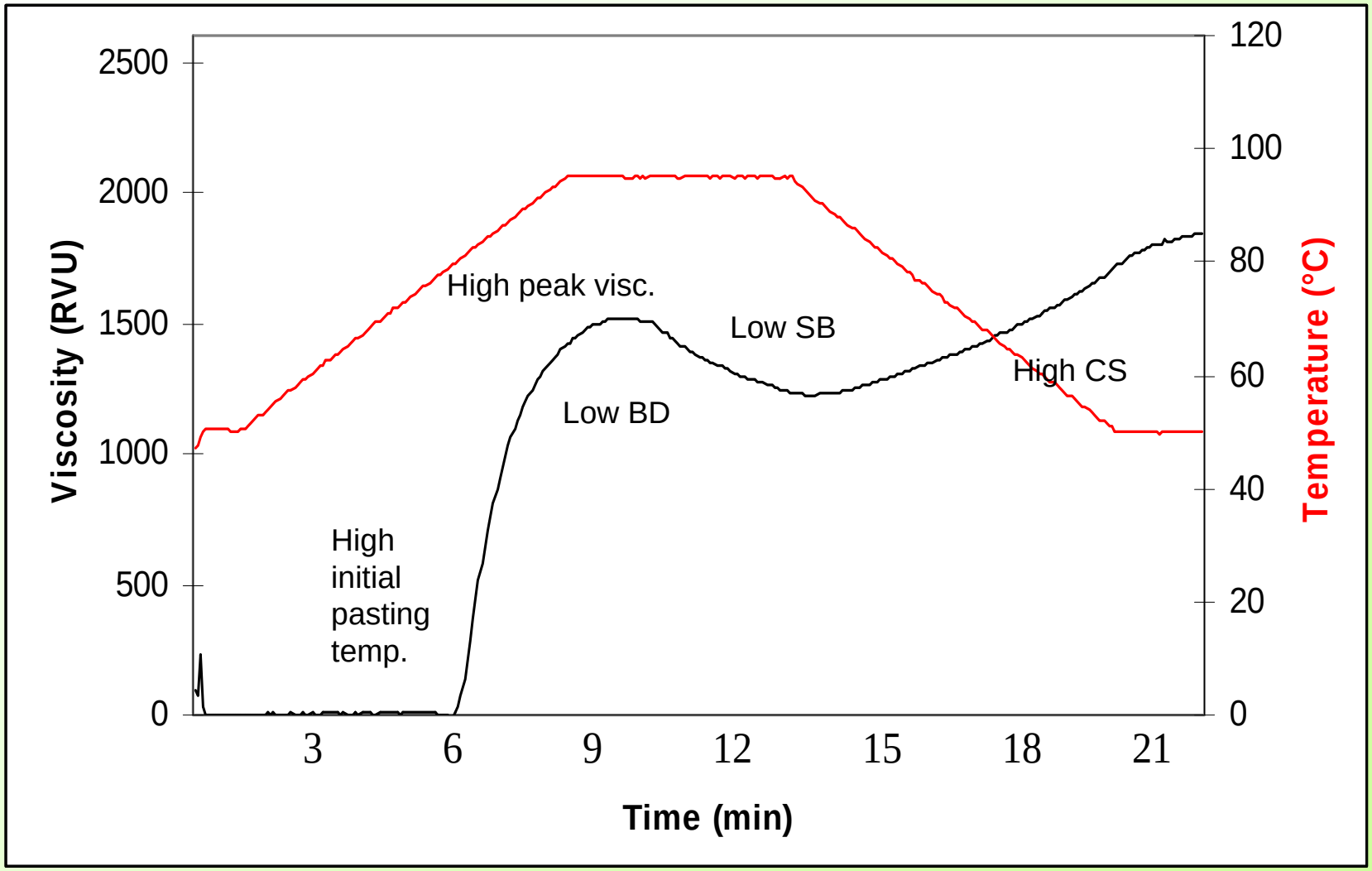
PV: peak viscosity, SB: Setback, CS : Consistency

BD: breakdown, HPV: hot paste viscosity

Pasting properties



Example : Native plantain French Clair RVA profile



- Heat resistance (high gelatinisation temperature and initial pasting temp)

  => high heat process tolerance (ex: industrial sauces)
- High peak viscosity (double to four time of a corn paste at 6%)
- High starch crystallinity => high GT like waxy starch
- Limited breakdown => mechanical shear resistance
- High gel consistency => high gel strength (textural properties for high starch concentrates ie gums, jellies)
- Low setback => low retrogradation (bread staling)

These pasting properties are then conferring to banana starch the potentiality to be substituted to modified starch (cross-linked starches) and replace to some extend some starch industrially produced with similar functional properties

Other banana starch specificities…

- Restricted swelling power and good stability => low glycaemic index and slow digestion
- Restricted solubility => opacity (ex: formulation of sauces)
- Low starch digestibility => resistance to amylase-catalyzed hydrolysis
- Resistant starch escape digestion => beneficial health effects

Conclusion

uniqueness of banana starch

Promising new base starch (as modified starch)

Superior properties to some existing starches and modified starches for specific niche application

Availability and bio-waste management challenge

Many potentialities to determine and exploit in coming research on Musaceae

Thank you for you attention

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